IS 12511-2 (2004): Springs - Disc Spring, Part 2: Specification [TED 21: Spring]

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भाग 2 विशिष्टि

(पहला पुनरीक्षण)

Indian Standard

SPRINGS — DISC SPRING

PART 2 SPECIFICATION

(First Revision)

ICS 21.160

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

August 2004

Price Group 6

FOREWORD

This Indian Standard (Part 2) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Automotive Springs and Suspension Systems Sectional Committee had been approved by the Transport Engineering Division Council.

The dimensions specified in this standard are intended to provide a framework for the preferred types of disc springs to be used. From the comparatively small number of types, it is possible to assemble a variety of combinations producing spring columns with wide variety of spring characteristics. Attempts to increase the range of disc springs conforming to this standard, for example, by inserting more closely graded standard sizes, cannot be recommended. The user should endeavour, as far as possible, to use only disc spring sizes specified in this standard. Other designs of disc springs differing from the dimensions specified in this standard constitute special orders. The works standards of the manufacturers will, however, continue to be available for such special orders.

The specified disc springs may be statically loaded up to $s \approx 0.75\ h$ without any risk of setting effects. When disc springs are subjected to fatigue loading, the fatigue fracture always starts on the underside of the disc. The greater of the theoretical tensile stresses in each case for $s \approx 0.75\ h_0$ at location II or III, respectively of the disc has been specified for each spring. The calculation has been based on Part 1 of this standard, the influence of the seating faces and, for Group 3 springs of the reduced disc thicknesses.

In order to differentiate these disc springs from other compression elements which are outwardly similar, this standard also contains quality specifications. Certain minimum requirements for disc springs are indispensable in order to achieve good fatigue strength values. It is recommended to adopt those minimum requirements also for non-standardized disc springs.

The revision of this standard was undertaken so as to align it with the base standard which is being revised. The following are the technical changes incorporated:

a) Grouping/classification as per thickness of the single disc.
b) Spring force, *F* in base standard which has been increased (*see* Tables 2, 3 and 4).
c) Requirement of compressive load in spring single disc has been added (*see* **9**).
d) Tensile load of spring disc has been changed in all categories and groups.
e) Tolerances in **8** is included.
f) Tolerances in **8.1** have been changed for thickness of disc. Moreover it has been further grouped in as per the classification.
g) Tolerance in overall height (*see* **8.3**) has been changed and has been relaxed considerably.
h) Tolerance on permissible deviation in spring force *F* for disc springs is given. The graph and test method to find it is provided.
j) Prestress load and relaxations are also suggested with respect to the various raw material classes.
k) A clause on testing is also introduced.
m) Moderate fatigue condition (*see* **12**) and development of various stresses in spring subjected to fatigue loading are included.
n) Requirement of surface roughness number has been added (*see* **15.1**).

In the preparation of this standard, considerable assistance has been derived from DIN 2093-1992 'Dimensions and quality of conical disc springs' issued by Deutsches Institut für D Normung (DIN).

The composition of the Committee responsible for the preparation of this standard is given at Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

SPRINGS — DISC SPRING

PART 2 SPECIFICATION

(First Revision)

1 SCOPE

1.1 This standard (Part 2) specifies requirements for the materials, dimensions, tolerances, and permissible stresses for conical disc springs. It includes graphs showing the permissible relaxation and the endurance life of such springs, as a function of stress.

1.2 The values specified in this standard apply to operating temperatures between 0 and 60°C.

1.3 The minimum requirements specified are intended to ensure the proper performance of conical disc springs and may also be applied to non-standardized springs.

1.4 The three series specified here represent groups of spring sizes which have met with general acceptance in practice.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1586 : 2000	Method for Rockwell hardness test for metallic material (scales A-B-C-D-E-F-G-H-K 15N, 30N, 45N, 15T, 30T and 45T) (*third revision*)
2507 : 1975	Specification for cold rolled steel strips for springs (*first revision*)
12511 (Part 1) : 2004	Springs—Disc spring : Part 1 Design and calculation (*under print*)
7001 : 1989	Springs — Shot peening of steel parts — Specification (*first revision*)

3 CONCEPT

Disc springs are annular coned elements that offer resistance to a compressive force applied axially. They may be designed as single discs or as discs stacked in parallel or in series, either singly or in multiples. They may be subjected to both static and fatigue loading, and may have ground end surfaces.

4 SYMBOLS

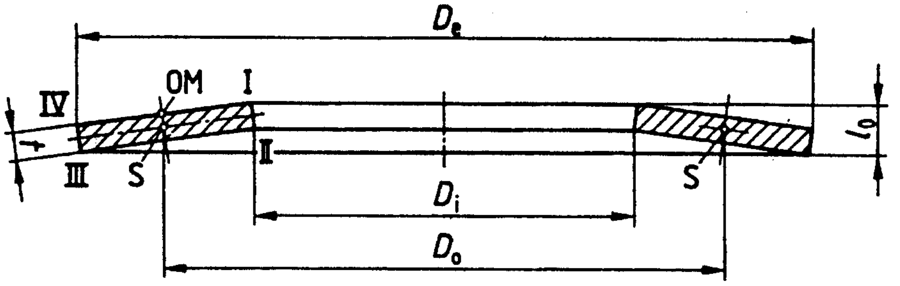
The following symbols and units shall apply (*see* Fig. 1):

		Unit
D_e	Outside diameter	mm
D_i	Inside diameter	mm
E	Modulus of elasticity	N/mm^2
F	Spring force of single disc	N
h_o	Operand (theoretical spring travel) down to the completely flat position $l_o - t$	mm
l_o	Overall height of unloaded single disc	mm
s	Spring travel of single disc (deflection)	mm
t	Thickness of single disc	
t'	Reduced thickness of single disc in the case of disc springs with seating faces (Group 3)	mm
σ	Theoretical stress	N/mm^2
σ_h	Mean fatigue stress associated with the deflection of springs subject to fatigue loading	N/mm^2
σ_U	Minimum fatigue stress	N/mm^2
σ_o	Maximum fatigue stress	N/mm^2
σ_H $(\sigma_o - \sigma_u)$	Range of stress	N/mm^2
σ_{OM}	Design stresses at the points designated OM I, II, III and IV (*see* Fig. 1)	N/mm^2
L_0	Length of springs stacked in series or in parallel, in the initial position	mm

5 CLASSIFICATION

This standard makes a distinction among three groups of springs, in accordance with Table 1.

Conical disc spring of group 1 or 2



Conical disc spring of group 3

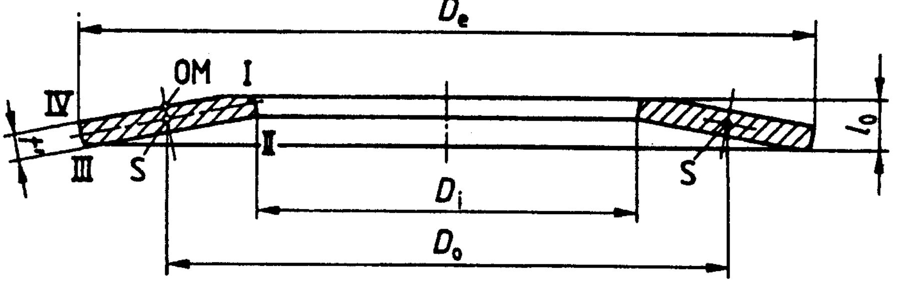


FIG. 1 CROSS SECTION OF A SINGLE DISC, INCLUDING THE RELEVANT POINTS OF LOADING

Table 1 Groups of Springs

(*Clause* 5)

Sl No.	Group	Thickness of Single Disc *t*	Single Disc with Ground Ends
(1)	(2)	(3)	(4)
i)	1	Less than 1.25	No
ii)	2	From 1.25 to 6	No
iii)	3	Over 6 up to 14	Yes

6 DIMENSIONS

The dimensions shall be as given in Tables 2, 3 and 4.

Table 2 Conical Disc Springs of Series A (with $\frac{D_e}{t} = 18$; $\frac{h_o}{t} = 0.4$, $E = 206\ 000$ N/mm², and $\mu = 0.3$)

(*Foreword*, and *Clause* 6)

Group	D_e	D_i	t or (t^{-1}) [1]	h_o	l_o	F	s	l_o-s	σ_{OM} [2]	σ_{II} [3] σ_{III}
	h_{12}	H_{12}				N	(where $s \approx 0.75\ h_o$)		N/mm²	N/mm²
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	8	4.2	0.4	0.2	0.6	210	0.15	0.45	-1 200	1 220*
	10	5.2	0.5	0.25	0.75	329	0.19	0.56	-1 210	1 240*
	12.5	6.2	0.7	0.3	1	673	0.23	0.77	-1 280	1 420*
	14	7.2	0.8	0.3	1.1	813	0.23	0.87	-1 190	1 340*
	16	8.2	0.9	0.35	1.25	1 000	0.26	0.99	-1 160	1 290*
1	18	9.2	1	0.4	1.4	1 250	0.3	1.1	-1 170	1 300*
	20	10.2	1.1	0.45	1.55	1 530	0.34	1.21	-1 180	1 300*
	22.5	11.2	1.25	0.5	1.75	1 950	0.38	1.37	-1 170	1 320*
	25	12.2	1.5	0.55	2.05	2 910	0.41	1.64	-1 210	1 410*
	28	14.2	1.5	0.65	2.15	2 850	0.49	1.66	-1 180	1 280*
	31.5	16.3	1.75	0.7	2.45	3 900	0.53	1.92	-1 190	1 310*
	35.5	18.3	2	0.8	2.8	5 190	0.6	2.2	-1 210	1 330*
	40	20.4	2.25	0.9	3.15	6 540	0.68	2.47	-1 210	1 340*
	45	22.4	2.5	1	3.5	7 720	0.75	2.75	-1 150	1 300*
2	50	25.4	3	1.1	4.1	12 000	0.83	3.27	-1 250	1 430*
	56	28.5	3	1.3	4.3	11 400	0.98	3.32	-1 180	1 280*
	63	31	3.5	1.4	4.9	15 000	1.05	3.85	-1 140	1 300*
	71	36	4	1.6	5.6	20 500	1.2	4.4	-1 200	1 330*
	80	41	5	1.7	6.7	33 700	1.28	5.42	-1 260	1 460*
	90	46	5	2	7	31 400	1.5	5.5	-1 170	1 300*
	100	51	6	2.2	8.2	48 000	1.65	6.55	-1 250	1 420*
	112	57	6	2.5	8.5	43 800	1.88	6.62	-1 130	1 240*
	125	64	8(7.5)	2.6	10.6	85 900	1.95	8.65	-1 280	1 330*
3	140	72	8(7.5)	3.2	11.2	85 300	2.4	8.8	-1 260	1 280*
	160	82	10(9.4)	3.5	13.5	139 000	2.63	10.87	-1 320	1 340*
	180	92	10(9.4)	4	14	125 000	3	11	-1 180	1 200
	200	102	12(11.25)	4.2	16.2	183 000	3.15	13.05	-1 210	1 230*
	225	112	12(11.25)	5	17	171 000	3.75	13.25	-1 120	1 140
	250	127	14(13.1)	5.6	19.6	249 000	4.2	15.4	-1 200	1 220

1) The values specified for t are nominal values. In the case of Group 3 springs, the values given in parentheses apply for t' (reduced thickness). Limit deviations for thickness are specified in **8.2**.

2) Design (compressive) stresses at the point designated *OM*, that is on the conical surface of the spring.

3) The values specified apply for the largest tensile stresses on the lower edges of the spring. The values specified with an asterisk (*) apply to the point designated II, those without an asterisk, to the point designated III.

NOTE — In the case of springs with ground ends (*see* Group 3 in **5**), the desired spring load, F (where s is equal to approximately $0.75\ h_o$), is to be obtained by reducing the thickness of single discs, t, which then gives the value t'. In the case of spring series *A* and *B*, t' shall be equal to approximately 0.94 t, and in the case of spring series *C*, it shall be equal to approximately 0.96 t.

Table 3 Conical Disc Springs of Series B (with $\frac{D_e}{t} = 28$; $\frac{h_o}{t} = 0.75$, $E = 206\ 000$ N/mm², and $\mu = 0.3$)

(*Foreword*, and *Clause* 6)

Group	D_e h_{12}	D_i H_{12}	t or (t^{-1})[1]	h_o	l_o	F N	s (where $s \approx 0.75\ h_o$)	l_o-s	σ_{OM}[2] N/mm²	σ_{II}[3] σ_{III} N/mm²
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	8	4.2	0.3	0.25	0.55	119	0.19	0.36	-1 140	1 330
	10	5.2	0.4	0.3	0.7	213	0.23	0.47	-1 170	1 300
	12.5	6.2	0.5	0.35	0.85	291	0.26	0.59	-1 000	1 110
	14	7.2	0.5	0.4	0.9	279	0.3	0.6	-970	1 100
	16	8.2	0.6	0.45	1.05	412	0.34	0.71	-1 010	1 120
1	18	9.2	0.7	0.5	1.2	572	0.38	0.82	-1 040	1 130
	20	10.2	0.8	0.55	1.35	745	0.41	0.94	-1 030	1 110
	22.5	11.2	0.8	0.65	1.45	710	0.49	0.96	-962	1 080
	25	12.2	0.9	0.7	1.6	868	0.53	1.07	-938	1 030
	28	14.2	1	0.8	1.8	1 110	0.6	1.2	-961	1 090
	31.5	16.3	1.25	0.9	2.15	1 920	0.68	1.47	-1 090	1 190
	35.5	18.3	1.25	1	2.25	1 700	0.75	1.5	-944	1 070
	40	20.4	1.5	1.15	2.65	2 620	0.86	1.79	-1 020	1 130
	45	22.4	1.75	1.3	3.05	3 660	0.98	2.07	-1 050	1 150
	50	25.4	2	1.4	3.4	4 760	1.05	2.35	-1 060	1 140
	56	28.5	2	1.6	3.6	4 440	1.2	2.4	-963	1 090
	63	31	2.5	1.75	4.25	7 180	1.31	2.94	-1 020	1 090
2	71	36	2.5	2.3	4.5	6 730	1.5	3	-934	1 060
	80	41	3	2.5	5.3	10 500	1.73	3.57	-1 030	1 140
	90	46	3.5	2.8	6	14 200	1.88	4.12	-1 030	1 120
	100	51	3.5	3.2	6.3	13 100	2.1	4.2	-925	1 050
	112	57	4	3.5	7.2	17 800	2.4	4.8	-963	1 090
	125	64	5	4	8.5	30 000	2.63	5.87	-1 060	1 150
	140	72	5	4.5	9	27 900	3	6	-970	1 110
	160	82	6	5.1	10.5	41 100	3.38	7.12	-1 000	1 110
	180	92	6		11.1	37 500	3.83	7.27	-895	1 040
	200	102	8(7.5)	5.6	13.6	76 400	4.2	9.4	-1 060	1 250
3	225	112	8(7.5)	6.5	14.5	70 800	4.88	9.62	-951	1 180
	250	127	10(94)	7	17	119 000	5.25	11.75	-1 050	1 240

1) The values specified for t are nominal values. In the case of Group 3 springs, the values given in parentheses apply for t' (reduced thickness). Limit deviations for thickness are specified in **8.2**.

2) Design (compressive) stresses at the point designated *OM*, that is on the conical surface of the spring.

3) The values specified apply for the largest tensile stresses on the lower edges of the spring. The values specified with an asterisk (*) apply to the point designated II, those without an asterisk, to the point designated III.

NOTE — In the case of springs with ground ends (*see* Group 3 in **5**), the desired spring load, F (where s is equal to approximately 0.75 h_o), is to be obtained by reducing the thickness of single discs, t, which then gives the value t'. In the case of spring series A and B, t' shall be equal to approximately 0.94 t, and in the case of spring series C, it shall be equal to approximately 0.96 t.

Table 4 Conical Disc Springs of Series C (with $\frac{D_e}{t} = 40$; $\frac{h_o}{t} = 1.3$, $E = 206\ 000$ N/mm², and $\mu = 0.3$)

(*Foreword,* and *Clause* 6)

Group	D_e	D_i	t or (t^{-1})[1]	h_o	l_o	F	s	l_o-s	σ_{OM}[2]	σ_{II}[3] σ_{III}
	h_{12}	H_{12}				N	(where $s \approx 0.75\ h_o$)		N/mm²	N/mm²
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	8	4.2	0.2	0.25	0.45	39	0.19	0.26	-762	1 040
	10	5.2	0.25	0.3	0.55	58	0.23	0.32	-734	980
	12.5	6.2	0.35	0.45	0.8	152	0.34	0.46	-944	1 280
	14	7.2	0.35	0.45	0.8	123	0.34	0.46	-769	1 060
	16	8.2	0.4	0.5	0.9	155	0.38	0.52	-751	1 020
	18	9.2	0.45	0.6	1.05	214	0.45	0.6	-789	1 110
1	20	10.2	0.5	0.65	1.15	254	0.49	0.66	-772	1 070
	22.5	11.2	0.6	0.8	1.4	425	0.6	0.8	-883	1 230
	25	12.2	0.7	0.9	1.6	601	0.68	0.92	-936	1 270
	28	14.2	0.8	1	1.8	801	0.75	1.05	-961	1 300
	31.5	16.3	0.8	1.05	1.85	687	0.79	1.06	-810	1 130
	35.5	18.3	0.9	1.15	2.05	831	0.86	1.19	-779	1 080
	40	20.4	1	1.3	2.3	1 020	0.98	1.32	-772	1 070
	45	22.4	1.25	1.6	2.85	1 890	1.2	1.65	-920	1 250
	50	25.4	1.25	1.6	2.85	1 550	1.2	1.65	-754	1 040
	56	28.5	1.5	1.95	3.45	2 620	1.46	1.99	-879	1 220
	63	31	1.8	2.35	4.15	4 240	1.76	2.39	-985	1 350
	71	36	2	2.6	4.6	5 140	1.95	2.65	-971	1 340
	80	41	2.25	2.95	5.2	6 610	2.21	2.99	-982	1 370
2	90	46	2.5	3.2	5.7	7 680	2.4	3.3	-935	1 290
	100	51	2.7	3.5	6.2	8 610	2.63	3.57	-895	1 240
	112	57	3	3.9	6.9	10 500	2.93	3.97	-882	1 220
	125	64	3.5	4.5	8	15 400	3.38	4.62	-956	1 320
	140	72	3.8	4.9	8.7	17 200	3.68	5.02	-904	1 250
	160	82	4.3	5.6	9.9	21 800	4.2	5.7	-892	1 240
	180	92	4.8	6.2	11	26 400	4.65	6.35	-869	1 200
	200	102	5.5	7	12.5	36 100	5.25	7.25	-910	1 250
	225	112	6.5(6.2)	7.1	13.6	44 600	5.33	8.27	-840	1 140
3	250	127	7 (6.7)	7.8	14.8	50 500	5.85	8.95	-814	1 120

[1] The values specified for t are nominal values. In the case of Group 3 springs, the values given in parentheses apply for t' (reduced thickness). Limit deviations for thickness are specified in **8.2**.

[2] Design (compressive) stresses at the point designated *OM*, that is on the conical surface of the spring.

[3] The values specified apply for the largest tensile stresses on the lower edges of the spring. The values specified with an asterisk (*) apply to the point designated II, those without an asterisk, to the point designated III.

NOTE — In the case of springs with ground ends (*see* Group 3 in 5), the desired spring load, F (where s is equal to approximately 0.75 h_o), is to be obtained by reducing the thickness of single discs, t, which then gives the value t'. In the case of spring series *A* and *B*, t' shall be equal to approximately 0.94 t, and in the case of spring series *C*, it shall be equal to approximately 0.96 t.

7 DESIGNATION

Designation shall include type of disc spring, nominal outside diameter, group of disc spring and the number of this standard.

Example:

A disc spring of Type A having outside diameter D_e = 40 of Group 2 shall be designated as:

Disc Spring A40GR2—IS 12511 (Part 1)

8 TOLERANCES

8.1 Tolerances on Diameter

8.1.1 For all springs, tolerance class h_{12} shall apply for the outside diameter D_e. Tolerance class H_{12} shall apply for the inside diameter D_i.

8.2 Tolerances on Thickness — (*see* Table 5).

Table 5 Thickness

Group	t or t'	Limit Deviations
(1)	(2)	(3)
1	From 0.2 to 0.6	+0.02 –0.06
	Over 0.6 to below 1.25	+0.03 –0.09
2	From 1.25 to 3.8	+0.04 –0.12
	Over 3.8 up to 6.0	+0.05 –0.15
3	Over 6.0 up to 14.0	± 0.10

NOTE — In the case of Group 3 springs, the limit deviations specified apply to the reduced thickness, t'.

8.3 Tolerances on Free Overall Height, l_0— (*see* Table 6).

Table 6 Overall Height

Group	t	Limit Deviations
(1)	(2)	(3)
1	Less than 1.25	+0.10 –0.05
	From 1.25 to 2.0	+0.15 –0.08
2	Over 2.0 up to 3.0	+ 0.20 –0.10
	Over 3.0 up to 6.0	+0.30 –0.15
3	Over 6.0 up to 14.0	± 0.30

9 TOLERANCE ON SPRING LOAD

9.1 Single Discs

The static spring load F, of a single disc in the initial position ($l_0 - s$) shall be determined for a spring in the loaded state, using a suitable lubricant. The flat plates between which the spring is to be compressed shall be hardened, ground, and polished.

Under normal circumstances, the values specified in Table 7 shall apply.

Table 7 Spring Load
(*Clauses* 9.1 *and* 11.1)

Group	t	Limit Deviations for F at l_0 - 0.75 h_0 Percent
(1)	(2)	(3)
1	Less than 1.25	+25 –7.5
2	From 1.25 to 3.0	+15 –7.5
	Over 3.0 up to 6.0	+10 –5
3	Over 6.0 up to 14.0	±5

NOTE — To comply with the specified tolerances, it is necessary to exceed the tolerance values specified for l_0 (*see* Table 6).

9.2 Springs Stacked in Series

9.2.1 Ten single discs stacked in series shall be used to determine the deviation in load between the loading curve and the unloading curve of springs stacked in series. The individual discs shall be centred about a mandrel in compliance with **19**. The flat plates between which the spring is to be compressed shall be hardened, ground, and polished.

9.2.2 Prior to testing, the spring shall be compressed to twice its design load, F (where $s \approx 0.75\ h_0$). At ($L_0 - 7.5\ h_0$) the spring load determined for the unloading curve shall make up at least the minimum percentages specified in Table 8 of the spring load determined for the loading curve (*see* Fig. 2).

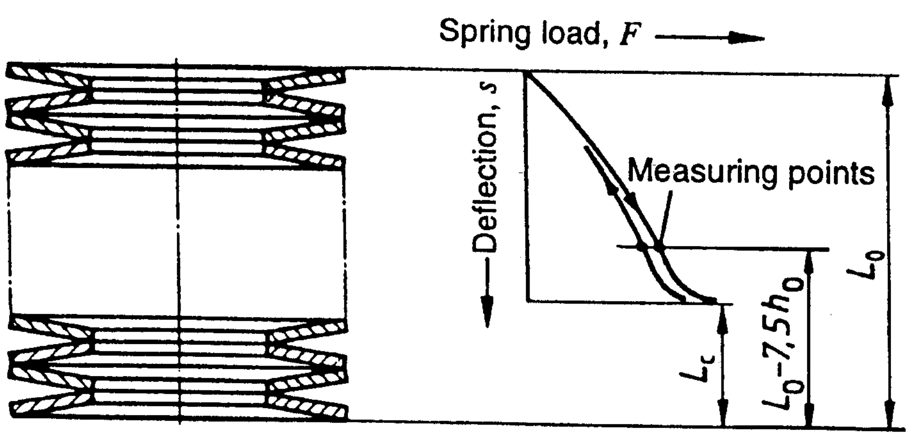


FIG. 2 MEASURING POINTS FOR LOADING AND UNLOADING CURVES

Table 8 Minimum Spring Load
(*Clause* 9.2.2)

Sl No.	Group	Minimum Spring Load (Unloading), As a Percentage, for Spring Series		
		A	B	C
(1)	(2)	(3)	(4)	(5)
i)	1	90	90	85
ii)	2	92.5	92.5	87.5
iii)	3	95	95	90

9.2.3 Within certain tolerances, the form of the actual individual discs will deviate from the geometrically ideal form of the stack. Together with the effect of friction, this results in a load/deflection curve for the stack that differs from that established for the sum of the results for the individual discs. Stacks of springs shall normally be tested with the arrangement used in practice.

10 CLEARANCE BETWEEN SPRING AND CENTERING ELEMENT

Means shall be provided to keep the spring in position, these being preferably internal, such as a mandrel. In the case of external positioning, a sleeve is preferred. The recommended amount of play between the spring and such a centring element is specified in Table 9, as function of the outside or inside diameter of the spring.

Table 9 Play

Sl No.	D_i or D_e	Approximate Play
(1)	(2)	(3)
i)	Up to 16	0.2
ii)	Over 16 up to 20	0.3
iii)	Over 20 up to 26	0.4
iv)	Over 26 up to 31.5	0.5
v)	Over 31.5 up to 50	0.6
vi)	Over 50 up to 80	0.8
vii)	Over 80 up to 140	1
viii)	Over 140 up to 250	1.6

11 PERMISSIBLE SET

11.1 Following heat treatment, each spring shall be prestressed in such a manner that the values specified in Table 7 are complied with when the spring is compressed to twice its design load, F (s $\approx$ 0.75 h_0).

11.2 In the case of springs subject to static loading the guideline values for relaxation illustrated in Fig. 3 may not be exceeded.

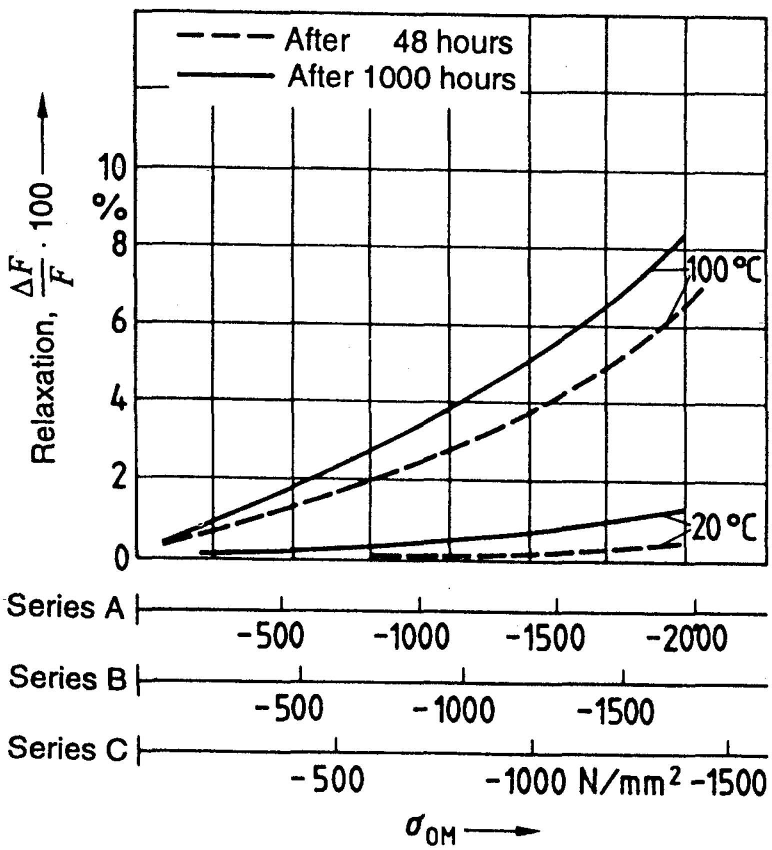


FIG. 3 ILLUSTRATION OF PERMISSIBLE RELAXATION FOR SPRINGS MADE FROM HIGH GRADE CHROMIUM ALLOY STEEL OR CHROMIUM — VANADIUM ALLOY STEEL

11.3 Where the service temperature exceeds 100°C, the spring manufacturer shall be consulted.

12 STRESSES IN SPRINGS SUBJECT TO STATIC LOADING OR MODERATE FATIGUE CONDITIONS

Steel that are subject to static loading or to moderate fatigue conditions, the design stress at the point designated *OM* (σ_{OM}), shall be approximately equal to the yield strength, *Re* of the material used. At higher stresses the springs may suffer from creep or relaxation (*see* **11**).

13 STRESSES IN SPRINGS SUBJECT TO FATIGUE LOADING

13.1 Minimum Initial Deflection to Avoid Cracking

Springs subject to fatigue loading shall be designed and installed in such a way that the initial deflection is from 0.15 h_0 to 0.20 h_0, in order to avoid cracking at the upper inner edge (point I, *see* Fig. 1) as a result of residual stresses from the setting process.

13.2 Stresses

13.2.1 Figures 4 to 6 illustrate the endurance life of disc springs subject to fatigue loading that have not been shot peened. They specify guideline values for the range of stress σ_H as a function of the minimum stress σ_U at three different numbers of stress cycles *N*, namely, where *N* is less than or equal to 2×10^6, equal to 10^5 and equal to 5×10^5. Intermediate values for other numbers of stress cycles may be estimated based on this information.

13.2.2 The information given in Fig. 4 to Fig. 6 represents the results of laboratory testing using fatigue testing equipment capable of producing sinusoidal loading cycles and the statistical results obtained for a 99 percent probability of endurance life. The test pieces were ten single discs with hardened surfaces, stacked in series, designed for use at ambient temperature, provided with an internal or external centring element with a smooth finish, having a minimum initial deflection S_1, from 0.15 h_0 to 0.20 h_0.

13.2.3 To ensure the expected endurance life of springs, they shall be protected from mechanical damage and other adverse conditions.

13.2.4 The stress cycles in practice are generally not sinusoidal in form. Where additional types of loading (for example sudden dynamic loading or that which results from resonance) act on the spring, it may be assumed that their endurance life will be shorter. Where

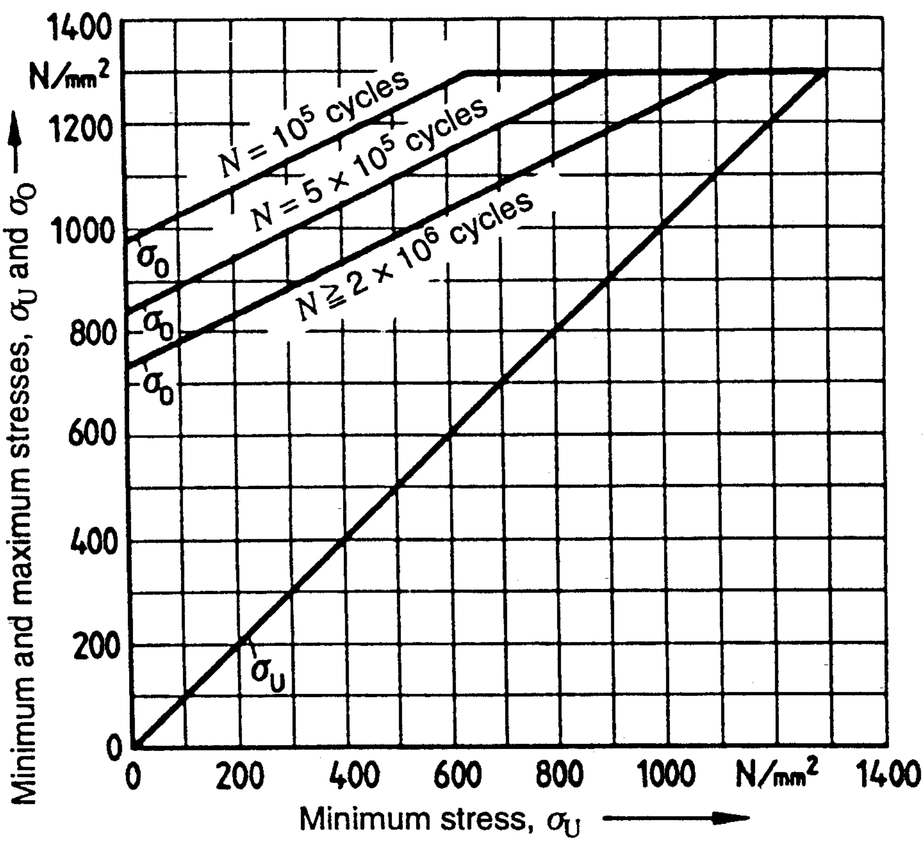


FIG. 4 GRAPHICAL REPRESENTATION OF ENDURANCE LIFE OF SPRINGS WHERE '*t*' IS LESS THAN 1.25 mm

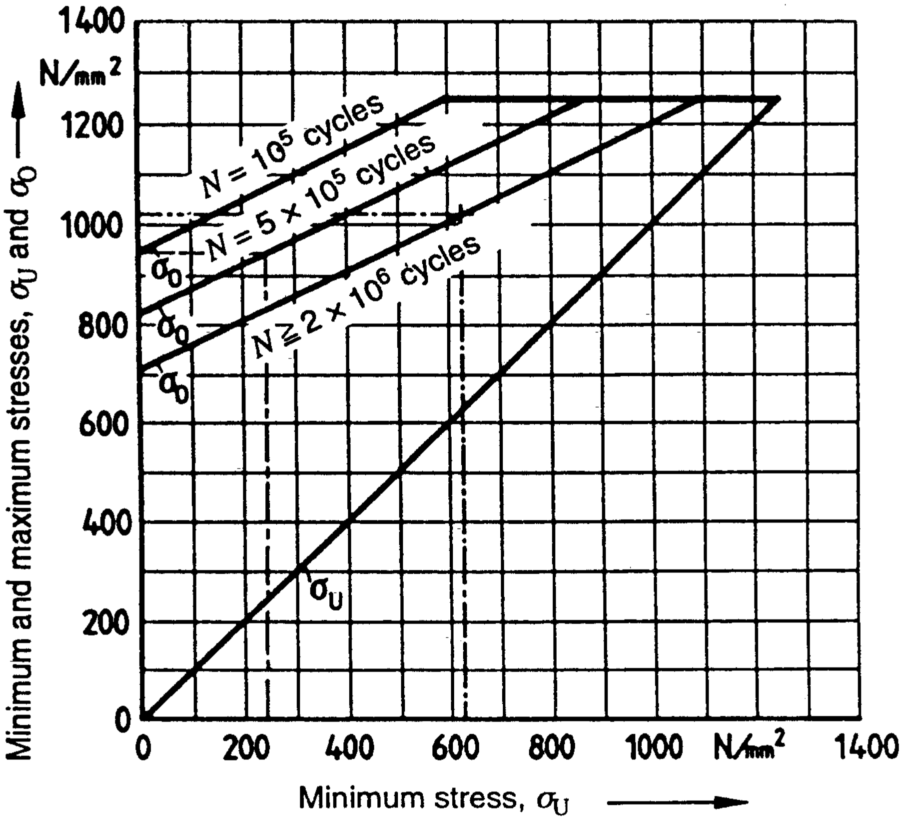


FIG. 5 GRAPHICAL REPRESENTATION OF ENDURANCE LIFE OF SPRINGS WHERE 1.25 mm $\leq t \leq$ 6 mm

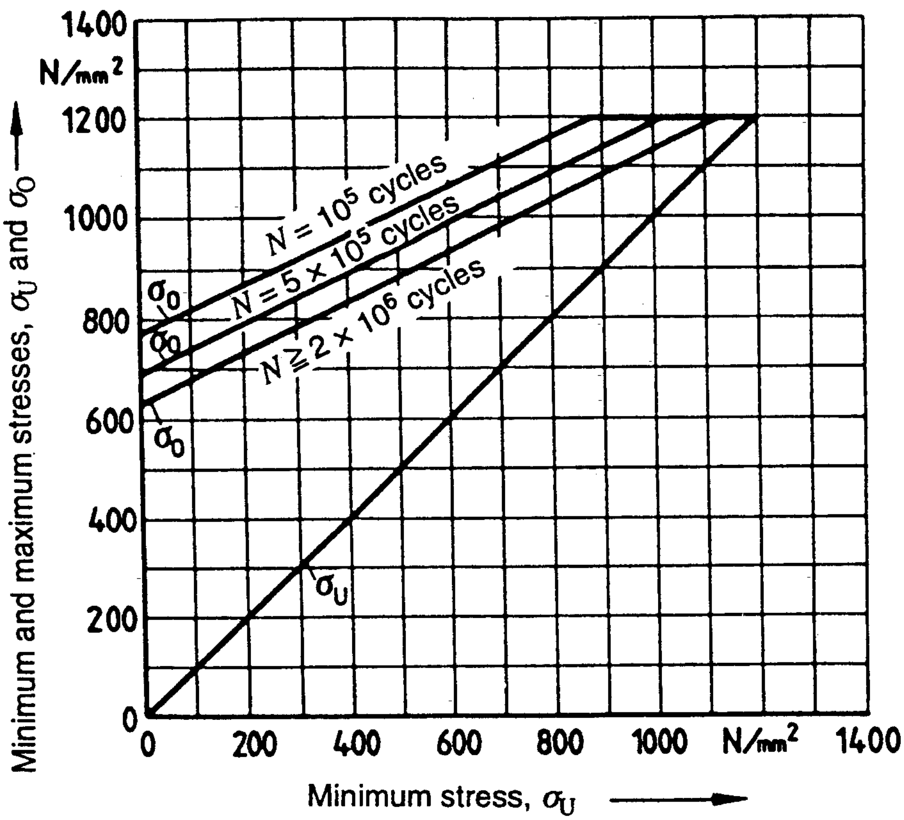


FIG. 6 GRAPHICAL REPRESENTATION OF ENDURANCE LIFE OF SPRINGS WHERE 6 mm $< t <$ 14 mm

such is the case, the values given in the above figures shall be converted by appropriate factors of safety. The spring manufacturer being consulted where necessary.

14 MATERIAL

Disc spring shall be made from any of the material specified below:

a) Steel Grade 50Cr4V2 conforming to IS 2507; and
b) For small sizes only in Group 1 up to 0.9 mm steel Grade 70C6 conforming to IS 2507.

15 FINISH

15.1 Manufacturing Methods and Surface Quality

A distinction is made among the following three groups (*see* 5 and Table 10).

Table 10 Surface Roughness of Various Manufacturing Processes

Group	Manufacturing Process	Surface Roughness[1) µm	
		Upper and Lower Surface	Outer and Inner Faces Edges
(1)	(2)	(3)	(4)
1	Stamped, cold formed, edges rounded	*Ra* < 3.2	*Ra* < 12.5
2[2)	Stamped, cold formed *De* and *Di* turned, edges rounded	*Ra* < 6.3	*Ra* < 6.3
	Stamped, cold formed, edges rounded	*Ra* < 6.3	*Ra* < 3.2
3	Cold or hot formed, turned on all sides, edges rounded	*Ra* < 12.5	*Ra* < 12.5

[1) The values specified do not apply to shot peened springs.

[2) Unless otherwise specified, the particular manufacturing process shall be up to the manufacturer (*see* 6 and 7).

15.2 The surface shall be free from defects such as scars, cracks and the effects of corrosion.

16 HARDNESS SURFACE AND SCRAGGING

16.1 The partial decarburization of disc springs after quenching and tempering shall not exceed 3 percent of the disc thickness.

16.2 Total decarburization shall not be permitted.

16.3 For static spring, the hardness of disc springs shall be within the range of 42 to 52 HRC (in case of Group 1 disc spring, the hardness shall be measured in accordance with IS 1586 in order to achieve good fatigue strength value with low relaxation. The load/length relaxation after 10^7 cycles shall not exceed 6 percent.

16.4 The surface must be flawless, that is, free from pit marks, cracks and corrosion.

16.5 Subsequent to heat treatment, every disc spring must be subjected to scragging in such a way that after loading at twice the spring force F for $s \approx 0.75\ h_0$, the overall height l_0 of the spring does not alter beyond the permissible deviation limits (*see* **8.3**).

16.6 Surface Hardening

The disc springs exposed to dynamic loading are recommended to undergo shot peening in accordance with IS 7001.

16.7 Protection Against Corrosion

16.7.1 The type of corrosion protection applied will depend on the intended application of the disc springs. This can be achieved among other methods by phosphating, burnishing or the application of protective metallic coatings, such as zinc or cadmium.

16.7.2 The processes are in use these days which involve the deposition of metallic coatings from aqueous solutions cannot with absolute certainty exclude the risk of hydrogen induced brittle fracture in the case of disc springs. For components with a hardness exceeding 40 HRC, the risk of brittle fracture is if anything even greater. This means that special precautions must be taken in respect of material selection, heat treatment and surface treatment. Therefore, when ordering electroplated disc springs, it is recommended to have prior consultation with the spring manufacturer.

16.7.3 Galvanic plating should, however, be avoided in the case of disc springs likely to be subjected to alternating loading, in favour of processes which do not have any adverse effects.

16.8 Guide Elements and Sealing Faces

The guide elements and sealing faces shall, where possible, be case-hardened (depth of case-hardening 0.8 mm) and exhibit a minimum hardness of 55 HRC. The surface of the guide element shall be smooth and preferably ground.

17 CALCULATION

17.1 The spring forces F for $s \approx 0.75\ h_0$ and the theoretical stresses σ for $s \approx 0.75\ h_0$ at location II and III, respectively have already been specified in this standard for disc springs in spring steel with $E = 206\ 000\ \text{N/mm}^2$. Attention is drawn to necessity of calculating lower and upper limits of stress at location II or III in the case of fatigue loading and of comparing these calculated values with a fatigue strength diagram.

17.2 The standardized disc springs are capable of being statically loaded up to $s \approx 0.75\ h_0$ without any risk of setting effects [*see* 12511 (Part 1)].

18 TESTING

18.1 Check of Dimensions and Other Spring Characteristics — (*see* Table 11).

Table 11 AQL Value of Spring Characteristics

Sl No.	Spring Characteristics	AQL Value
(1)	(2)	(3)
i)	Major characteristics: Spring load, F (where $s = 0.75\ h_0$) Outside diameter, D_e Inside diameter, D_i	1
ii)	Minor characteristics: Free overall height in initial position, l_o Spring thickness, t or t' Surface roughness, R_a	1.5

18.2 Hardness Testing

Rockwell hardness testing shall be carried out in accordance with IS 1586. The indentation shall be made on the upper surface of the spring, at a point that lies centrally between the inner and outer edges.

19 OTHER RELEVANT REQUIREMENTS

Where possible, the centering element and the seat shall be made from case-hardened materials, with a case depth of about 0.8 mm, and have a hardness of 55 HRC. The surface of the centering element shall be smooth and, where possible polished. It shall be permitted to use unhardened centering elements where the spring is subject to static loading.

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Automotive Springs and Suspension Systems Sectional Committee, TED 21

Organization	*Representative(s)*
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Akal Springs Pvt Ltd, Ludhiana	GENERAL MANAGER
All India Springs Manufacturers Association, Mumbai	SHRI A. A. MIRCHANDANI
Ashok Leyland Ltd, Chennai	SHRI APPALARAJU SHRI U. JAIKRISHNA (*Alternate*)
Association of State Road Transport Undertakings, New Delhi	SHRI A. S. LAKRA SHRI P. M. PHATE (*Alternate*)
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CQA (OFV) Vehicle Factory, Jabalpur	GENERAL MANAGER
Gabriel India Ltd, Mumbai	SHRI K. SUNDARARAMAN SHRI S. K. BHAUMICK (*Alternate*)
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Jamna Auto Industries Ltd, Yamuna Nagar	SHRI D. S. GILL SHRI B. K. KHANDELWAL (*Alternate*)
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Director (TED), BIS

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BUREAU OF INDIAN STANDARDS

Headquarters :

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002 — Telegrams : Manaksanstha
Telephones : 2323 0131, 2323 33 75, 2323 9402 — (Common to all offices)

Regional Offices :		Telephone
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